DSN Test and Training System, Mark III-77

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Implementation of the DSN Test and Training System, Mark III-77, throughout the network has been completed. The Mark III-77 system, as configured, has supported testing and training for the Voyager and Pioneer Venus 1978 missions and all other ongoing, inflight missions. Multimission functions of the system will provide some capabilities for initial DSN Test and Training preparations for the Galileo Project. DSN Test and Training System capabilities include functions performed in the Deep Space Stations, Ground Communications Facility, and Network Operations Control Center.

I. System Definition

A. General

The DSN Test and Training System is a multiple-mission system which supports Network-wide testing and training by inserting test signals and data into subsystems of the Deep Space Stations (DSS), the Ground Communications Facility (GCF), and the Network Operations Control Center (NOCC). The system includes capabilities for:

(1) On-site testing of the DSS portion of each DSN system.

(2) Local testing of the NOCC portion of each DSN system.

(3) End-to-end testing of each DSN system, including DSS, GCF, and NOCC functions.

Figure 1 describes the functions, elements, and interfaces of the system. This article updates the system description published in Ref. 1.

B. Key Characteristics

Design goal key characteristics of the DSN Test and Training System are:

(1) Capability to function without alteration of DSN operational configurations.

(2) Utilization of mission-independent equipment for DSN testing and training functions.

(3) Capability to exercise NOCC, GCF, and DSS simultaneously for end-to-end testing of each DSN system.

(4) Capability to supply test data to all DSN systems simultaneously.

(5) Capability to support network loading tests with a combination of actual and simulated data streams.

(6) Accommodation of flight-project-supplied simulation data via GCF.

(7) Accommodation of other data sources, as follows:

(a) Spacecraft test data via JPL Compatibility Test Area (CTA 21).

(b) Spacecraft prelaunch data via Merritt Island, Florida, Spacecraft Compatibility-Monitor Station (STDN (MIL 71)).

C. System Usage

Major testing and training activities supported by the DSN Test and Training System are summarized below:

(1) Performance calibrations and prepass readiness verifications.

(2) Real-time diagnostics and fault isolation.

(3) DSN implementation activities and performance testing of DSN systems, DSS subsystems, and NOCC subsystems.

(4) DSN operational verification tests to prepare for mission support.

(5) Flight project ground data system tests, mission simulations, and operational readiness tests.

II. Mark III-77 System Implementation

A. Status

A functional block diagram showing the data-flow and signal-flow paths of the DSN Test and Training System, Mark III-77, is shown in Fig. 2. Implementation of the Mark III-77 system throughout the network was completed when DSS 11 returned to operation in early 1978.

Upgrading of the DSS portions of the system has been a part of the DSN Mark III Data Subsystems (MDS) implementation project, which began in 1976.

All system capabilities which were required during 1978 were initially implemented prior to 1978.

B. Mission Set

The Mark III-77 configuration of the DSN Test and Training System includes all elements of the system required for support related to the following mission set:

(1) Viking Orbiters 1 and 2 and Viking Landers 1 and 2 (extended mission).

(2) Pioneers 6 through 9.

(3) Pioneers 10 and 11.

(4) Helios 1 and 2.

(5) Voyagers 1 and 2 (including planetary encounters).

(6) Pioneer Venus 1978 (PV'78) Orbiter and Multiprobe.

C. New Capabilities

(1) Program software has been provided to perform System Performance Test (SPT) functions for the DSS Radio Science System.

(2) The System Performance Test Executive and related procedures have been modified so that SPT software can be effectively utilized to support both System Performance Tests and Computer Aided Countdowns (prepass readiness tests).

III. Deep Space Station Functions

A. DSS Test and Training Subsystem

The functions of the DSS Test and Training Subsystem and the related interfaces are shown in Fig. 3.

(1) Telemetry simulation and conversion. The telemetry simulation and conversion functions are performed by the Simulation Processor Assembly (SPA) and the Simulation Conversion Assembly (SCA), as diagrammed in Fig. 4. Digital and analog capabilities are itemized in Tables 1 and 2, respectively.

(2) System performance test functions. The system performance test functions are performed by the SPT Software Assembly, as diagrammed in Fig. 5.

B. Receiver-Exciter Subsystem

The Receiver-Exciter Subsystem provides the following test and training functions:

(1) Generation of simulated S- and X-band downlink carriers.

(2) Modulation of telemetry subcarriers from the SCA onto simulated carriers.

(3) Variable attenuation of simulated downlink carrier signal level under control of the SPA.

(4) Translation of S-band exciter uplink frequencies to S- and X-band downlink frequencies for tracking system calibrations and performance testing.

(5) Generation of simulated Pioneer Venus entry probe carriers at DSS 14 and 43.

C. Antenna Microwave Subsystem

The Antenna Microwave Subsystem provides the following test and training functions:

(1) Routing of simulated downlink carriers to masers and/or receivers.

(2) Mixing of simulated S-band downlink carriers.

D. Transmitter Subsystem

The Transmitter Subsystem includes provision for feeding the transmitter output into a dummy load to support Command System and Tracking System test operations.

E. Frequency and Timing Subsystem

The Frequency and Timing Subsystem provides the following support functions to the DSS Test and Training System:

(1) Time code, to the SPT Assembly, and reference frequencies to the SCA and SPT Assembly.

(2) Generation and distribution of a simulated time signal which can be substituted for the true GMT input to the various DSS subsystems. This capability is provided to support realistic mission simulations in flight project testing and training activities.

F. Pre- and Post-Detection Recording Subsystem

One tape unit of the Pre- and Post-Detection Recording (PPR) Subsystem was used to play simulated data and subcarriers into the Pioneer Venus entry probe carrier simulators at DSS 14 and DSS 43. The CTA 21, SCA, and PPR were used to prepare the simulated data tapes that were used as inputs.

IV. Ground Communications Facility Functions

The DSN Test and Training System utilizes the Ground Communications Facility Subsystems for communicating data and information between the Network Operations Control Center (NOCC) or any Mission Operations Center (MOC) and the Deep Space Stations.

A. High-Speed Data Subsystem

The High-Speed Data Subsystem provides the following:

(1) Transmission of text messages, control messages, low- to medium-rate simulated telemetry data, and simulated command data to any DSS from the NOCC or from any MOC.

(2) On-site loop-back of test data for systems performance testing and readiness verifications in the DSS.

B. Wideband Data Subsystem

The Wideband Data Subsystem provides the following:

(1) Transmission of simulated high-rate telemetry data to the 34- and 64-m subnets (DSS's 12, 14, 43, and 63), the Compatibility Test Area (CTA 21), in Pasadena, California, and STDN (MIL 71) at Merritt Island, Florida, from the NOCC or from any MOC having wideband capability.

(2) On-site loop-back of test data for telemetry system performance testing and readiness verification in the stations which have wideband capability.

C. Teletype and Voice Subsystems

The Teletype and Voice Subsystems provide for communication of information for purposes of test coordination and monitoring the status of the DSN Test and Training System.

V. Network Operations Control Center Functions

A. NOCC Test and Training Subsystem

Functions and interfaces of the NOCC Test and Training Subsystem are shown in Fig. 6. Subsystem data flow is diagrammed in Fig. 7. Test and training capabilities presently implemented in the Network Operations Control Center are as follows:

(1) Off-line generation of recordings of high-speed data blocks for testing of the real-time monitors in the NOCC Tracking, Telemetry, Command, Radio Science, and Monitor and Control Subsystems.

(2) Output of text and control messages to the DSS for remote configuration and control of the SPA and SCA in support of DSN Operational Verification Tests.

(3) Selection of stored data blocks and output of the data to the DSS for system readiness verification.

B. DSN Test and Training System Control Console

A DSN Test and Training System Control Console in the Network Data Processing Area provides keyboard, card reader, magnetic tape unit, volatile display, and character printer for operation of the Test and Training System separate from the operations of the other DSN systems.

VI. Compatibility Test Area (CTA 21)

The facilities of the Compatibility Test Area have been utilized to support non-real-time system performance tests for validation of the Radio Science Subsystem.

VII. Future Planning

Effort has commenced toward development of the DSN Test and Training System, Mark III-81. This effort will require development of functional requirements and identification of system configurations that will be required to support both Simulation and System Performance Test functions in the 1981-1985 time frame.

Initial DSN Test and Training requirements in preparation for the Galileo mission are to support the upgrade of the DSS and NOCC Telemetry Subsystems and to support the implementation of CTA 21 for DSN-Spacecraft Compatibility Tests.

It is planned that these initial requirements can be supported by the existing DSN Test and Training System, Mark III-77, with minimal upgrades to support new data types. It is, however, expected that the new DSN Test and Training System, Mark III-81, will be required to support the full data system test and training requirements of Galileo and future projects.

References

1. Thorman, H. C., "DSN Test and Training System, Mark III-77," in *The Deep Space Network Progress Report 42-44*, pp. 4-15, Jet Propulsion Laboratory, Pasadena, Calif., Apr. 15, 1978.
2. Yee, S. H., "Modification of Simulation Conversion Assembly for Support of Voyager Project and Pioneer Venus 1978 Project," in *The Deep Space Network Progress Report 42-39*, pp. 100-108, Jet Propulsion Laboratory, Pasadena, Calif., June 15, 1977.
3. Friedenberg, S. E., "Pioneer Venus 1978 Multiprobe Spacecraft Simulator," in *The Deep Space Network Progress Report 42-38*, pp. 148-151, Jet Propulsion Laboratory, Pasadena, Calif., Apr. 15, 1977.

Table 1. DSS Test and Training Subsystem digital telemetry simulation capabilities

Capability	26-meter DSS, MIL 71	64-meter DSS, CTA 21
Maximum number of simultaneous real-time data streams	2 channels	Viking extended mission, 4 channels Other missions, 3 channels
Bi-orthogonal (32, 6) comma-free block coding	Viking, 2 channels Other missions, none	Viking, 3 channels Other missions, none
Short-constraint-length convolutional coding (k=7, r=1/2 or 1/3)	Voyager, rate = 1/2 2 channels Future missions, rate = 1/3, 1 channel	Voyager, rate = 1/2 3 channels Future missions, rate = 1/3, 2 channels
Long-constraint-length convolutional coding (k=32, r=1/2)	Helios, 1 channel Pioneer 10/11, 2 channels Pioneer Venus, 2 channels	Helios, 1 channel Pioneer 10/11, 2 channels Pioneer Venus, 3 channels
Variable rate control	1 bps to 600 ksps on 1 channel 1 bps to 190 ksps on 1 additional channel	1 bps to 600 ksps on 2 channels 1 bps to 190 ksps on 1 additional channel
Selection of discrete rates	8-1/3, 33-1/3 bps on each of 2 channels (for Viking)	8-1/3, 33-1/3 bps on each of 3 channels (for Viking)

Table 2. DSS Test and Training Subsystem analog telemetry simulation capabilities

Capability	26-meter DSS, MIL 71	64-meter DSS, CTA 21
Data and subcarrier signal conditioning, phase-shift keyed modulation	2 subcarriers	Viking extended mission, 4 subcarriers Other missions, 3 subcarriers
Subcarrier frequency output	512 Hz to 1.25 MHz, 1/4-Hz resolution	512 Hz to 1.25 MHz, 1/4-Hz resolution
Modulation-index angle control	Controllable from 0 to 89 deg on each subcarrier	Controllable from 0 to 89 deg on each subcarrier
Subcarrier mixing and downlink carrier biphase modulation	Single or dual subcarriers onto each of 2 S-band test carriers or 1 S-band and 1 X-band	Single or dual subcarriers onto each of 3 test carriers or 2 S-band and 1 X-band
Downlink carrier signal level	Attenuation of 0 to 40 dB on each test carrier output	Attenuation of 0 to 40 dB on each test carrier output

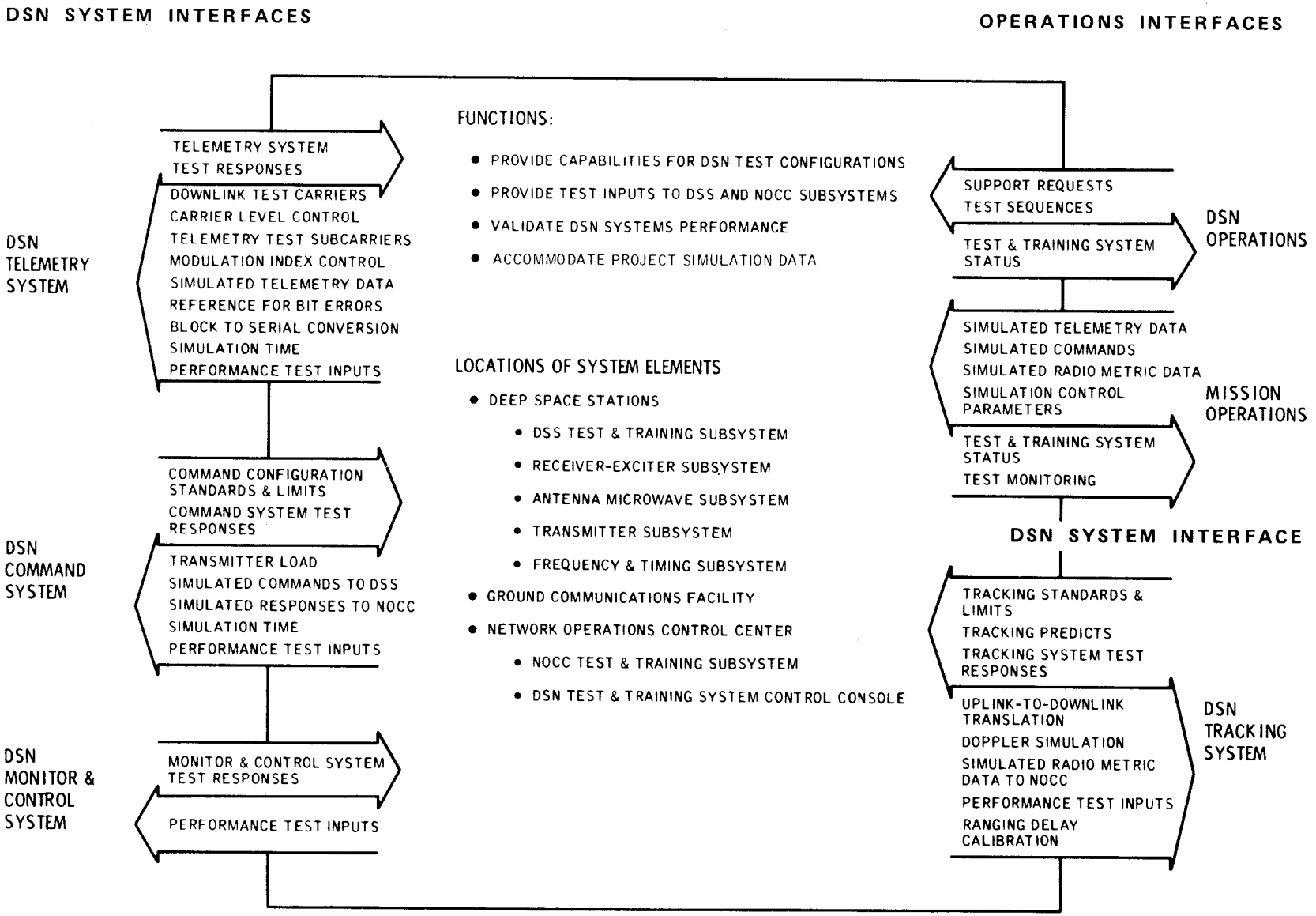

Fig. 1. DSN Test and Training System functions and interfaces

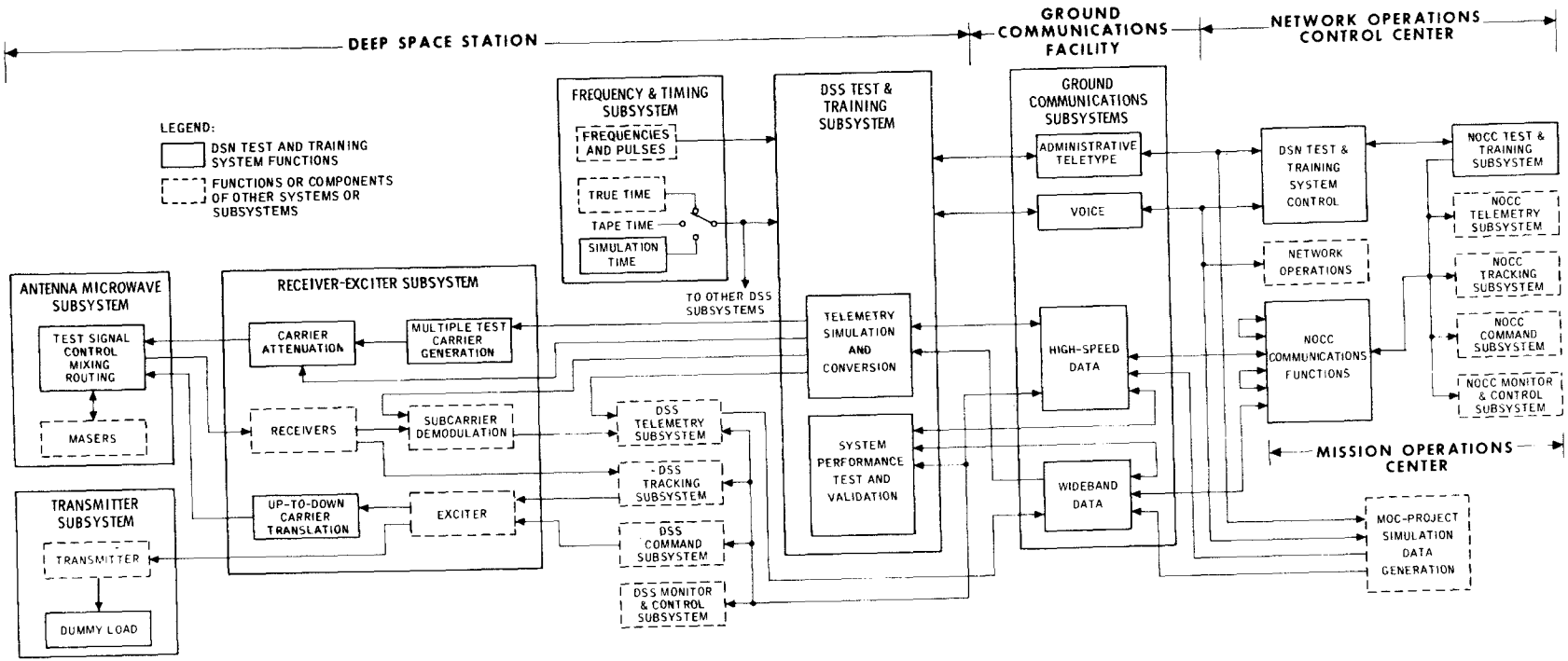

Fig. 2. DSN Test and Training System, Mark III-77, functional block diagram

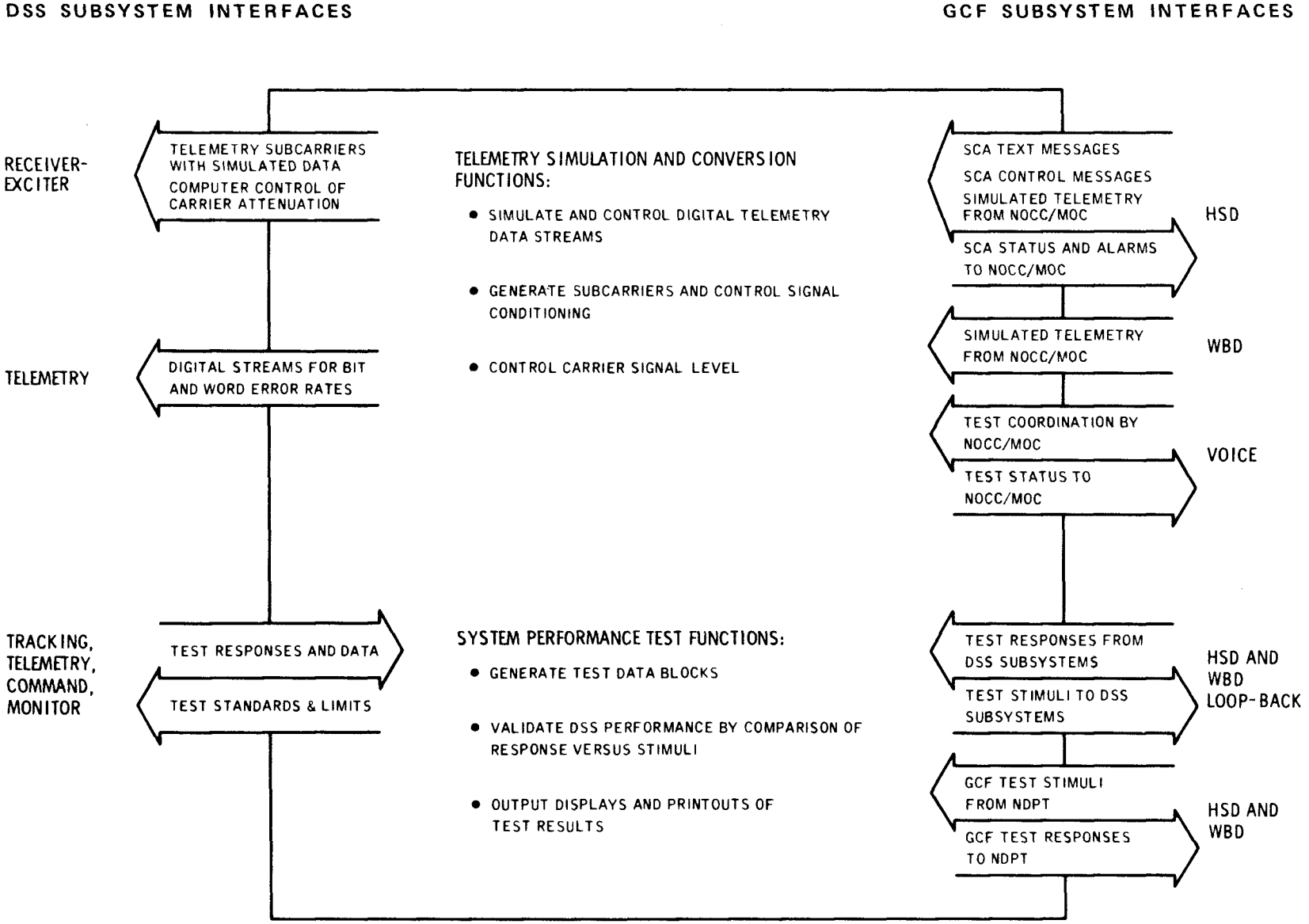

Fig. 3. DSS Test and Training Subsystem functions and interfaces

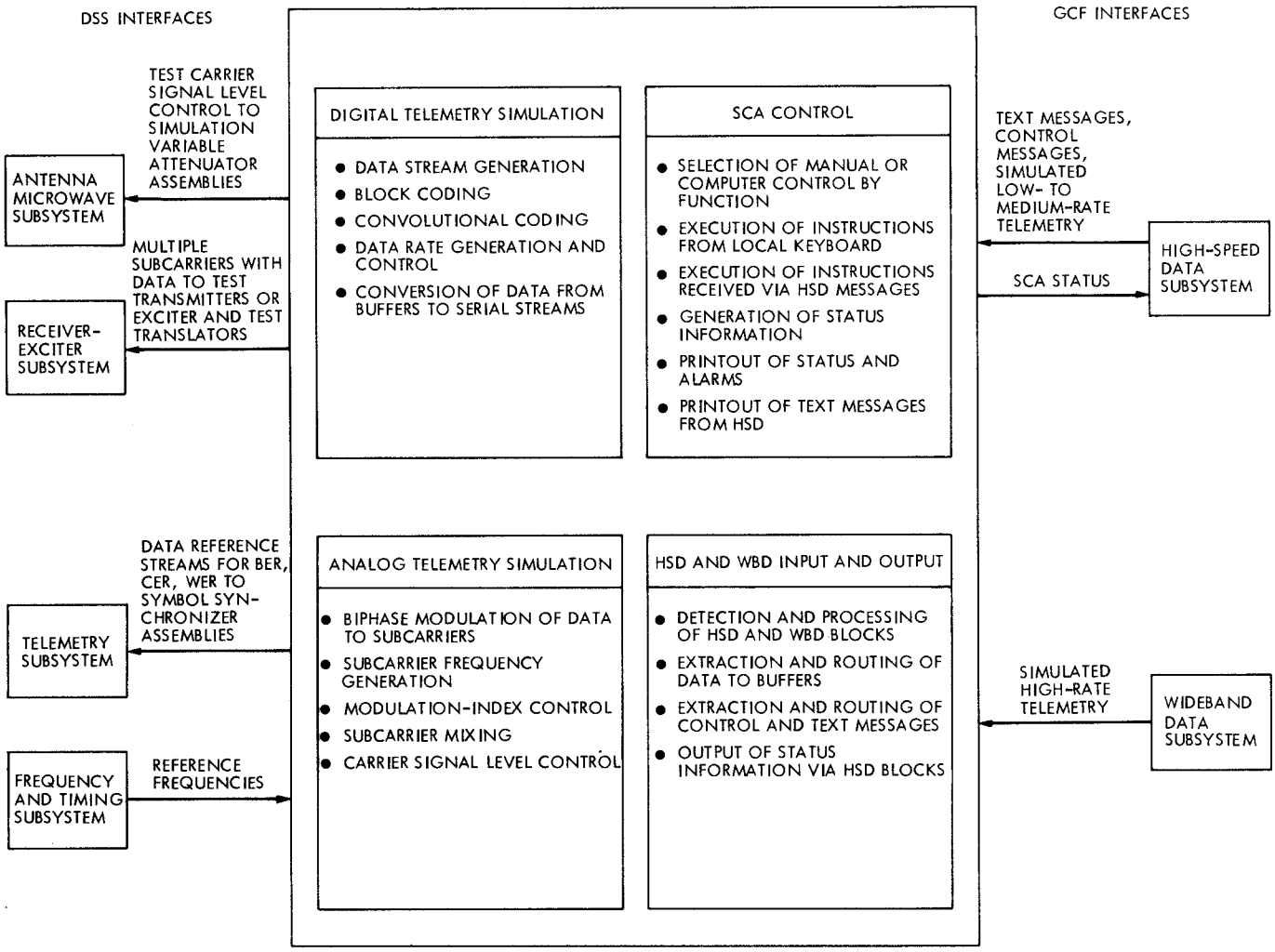

Fig. 4. Telemetry simulation and conversion functions and data flow

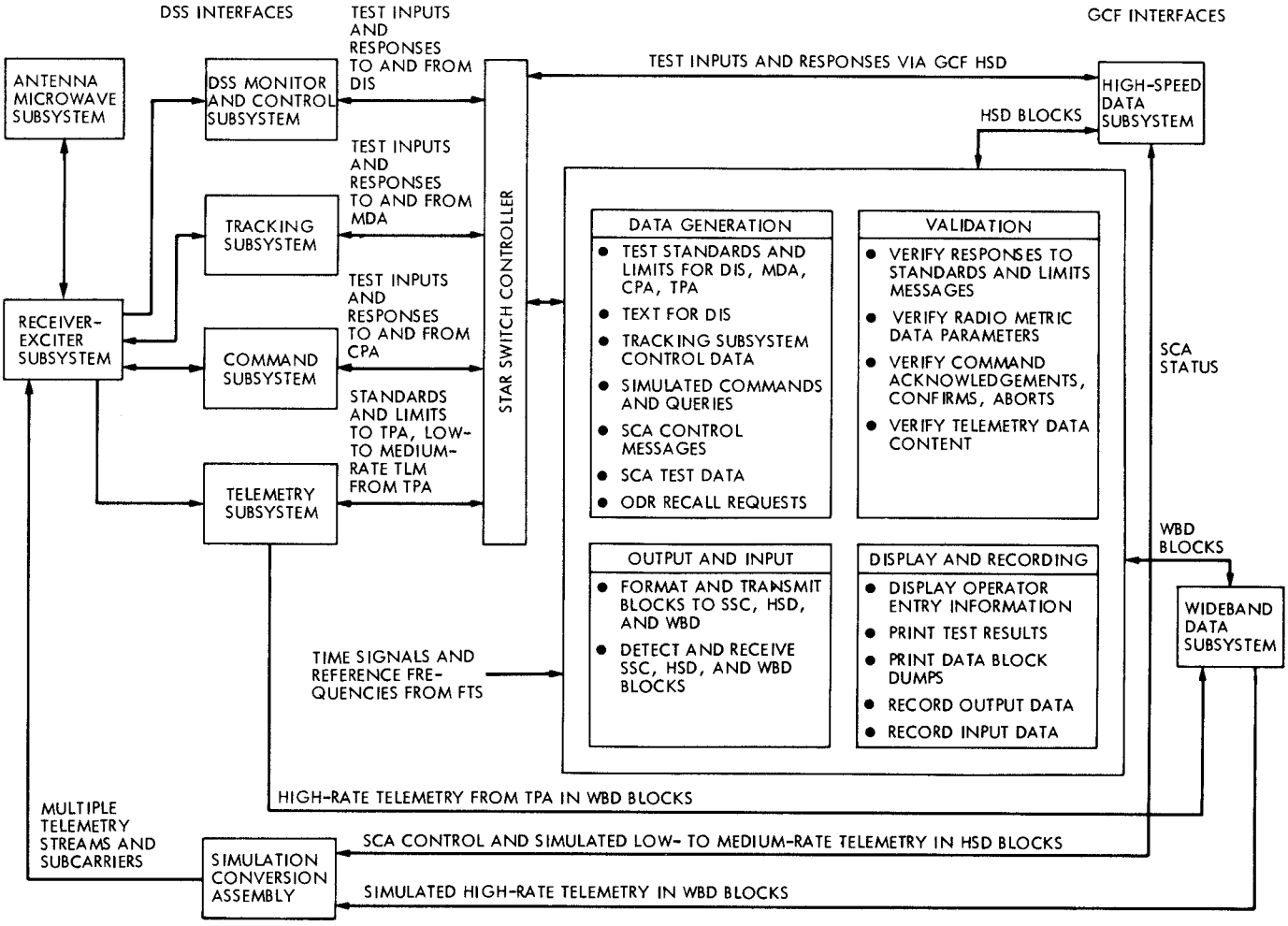

Fig. 5. System performance test functions and data flow

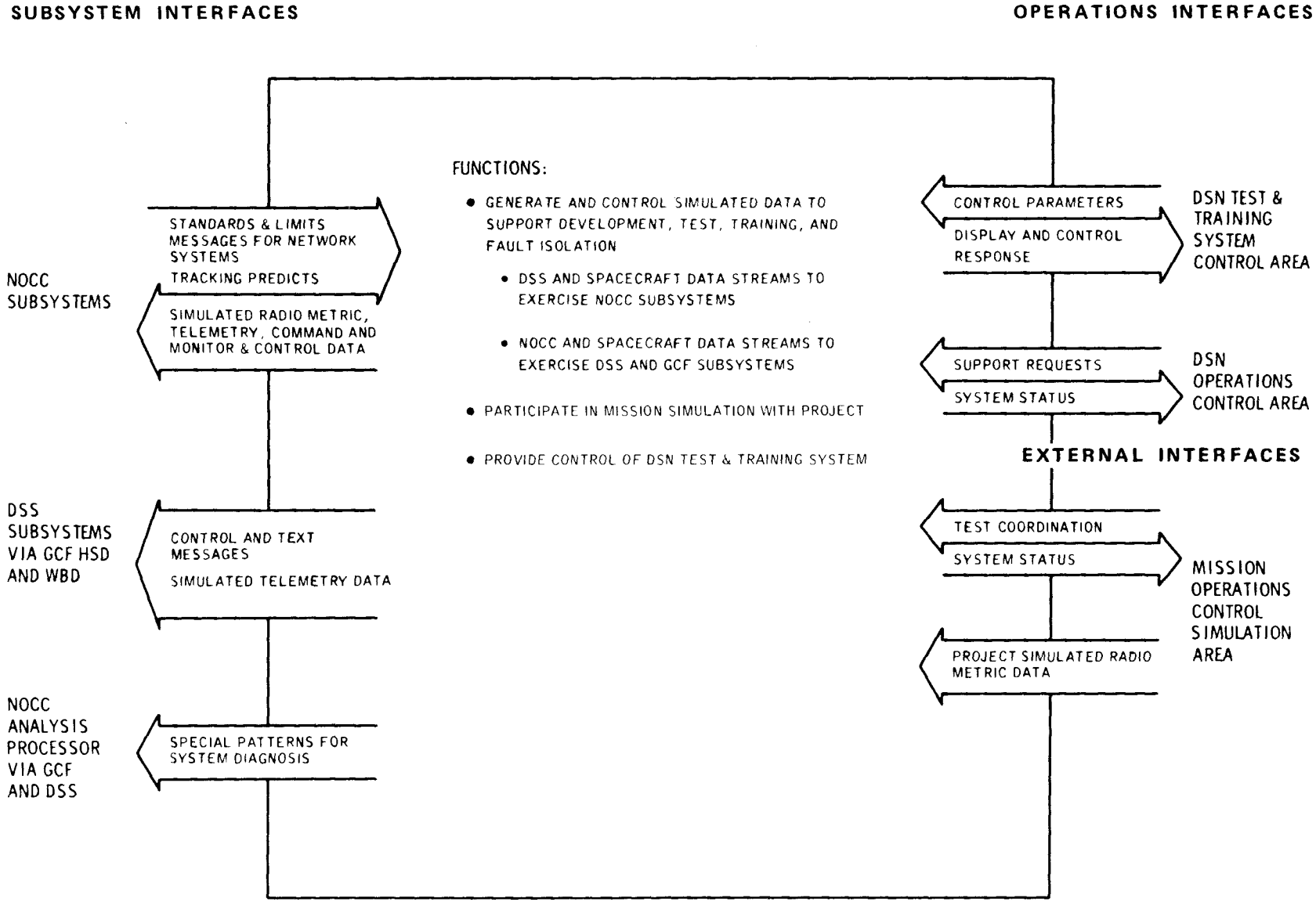

Fig. 6. NOCC Test and Training Subsystem functions and interfaces

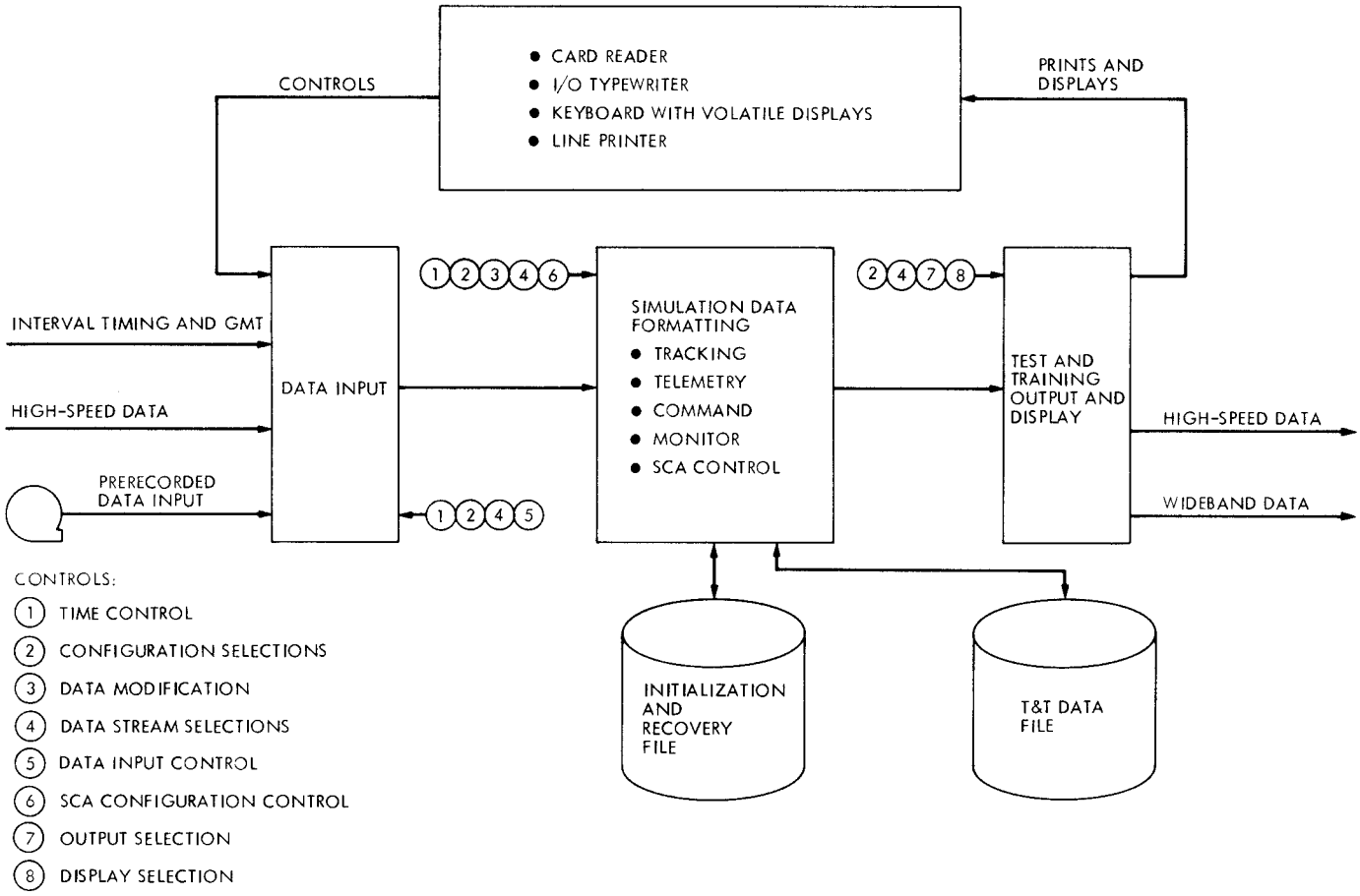

Fig. 7. NOCC Test and Training Subsystem data flow